Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

PCG31-07 会場:301A 時間:5 月 23 日 10:30-10:45

高波長分解能赤外ヘテロダイン分光器を用いた惑星大気研究
Study of planetary atmospheric dynamics, photochemistry, and meteorology using Mid-Infrared LAser Heterodyne Instrument

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In this paper, an overview of the science addressable with Mid-Infrared LAser Heterodyne Instrument (MILAHI) will be given. The list is certainly not exhaustive and proposals for future projects are very welcome. With the configuration described below the instrument MILAHI can be used for research in the atmospheres of solar system objects, i.e. planets, moons, comets, the Earth and the Sun. Extra solar objects like stars and stellar envelopes, proto-planetary disks or even exoplanets are possible targets of interest. MILAHI is easily transportable and widely usable for second-generation instrument for the airborne observatory, and large telescope project at Antarctic (Ichikawa, private communications).

Many molecules of atmospheric and astronomical interest exhibit rotational-vibrational spectra in the middle infrared regime. Fully resolved molecular features with high spectral resolution are possible retrieval of many physical parameters, such as density, velocity, pressure, excitation condition, temperature, and the vertical information from single line profile.

In mid-infrared wavelength region, the highest spectral resolution is provided by the infrared heterodyne technique (Kostuik and Mumma, 1983). It is for the applications to astronomy and planetary atmospheric science in 7-13 micron wavelength at a spectral resolution of up to 10E7-8 with a very high sensitivity. Infrared heterodyne spectroscopy has been applied to study of planetary atmosphere (Goldstein et al., 1991; Kostuik, 1996; Kostuik et al., 2000; Fast et al., 2006; Fast et al., 2011; Sonnabend et al., 2012; Sornig et al., 2012) to date.

We have developed a new infrared heterodyne instrument, called Mid-Infrared LAser Heterodyne Instrument (MILAHI), for our dedicated new telescope (1.8m) at the summit of Mt. Haleakala, Hawaii. This project would be milestone in order to increase our understanding of various temporal variability (diurnal, seasonal, and solar cycle effect) of planetary atmospheric dynamics, photochemistry, and meteorology.

Remarkable advantages of this instrument are as follows: (i) ultra-high velocity resolution (up to 10 m/s, corresponding to 10E7 wavelength resolving power) with a bandwidth of two times 1 GHz, (ii) previously unheard of compactness within 1 plate (600mm x 600mm) including the calibrators, (iii) excellent system noise temperature less than 2700 K at 9.6 micron wavelength. In order to provide wider wavelength range, a room-temperature type quantum cascade laser was applied for the first time. Its operating spectral range achieved to be 5 cm-1. As the backend spectrometer, a compact digital FFT spectrometer was also first applied for our system in order to obtain (a) a high frequency resolution, (b) stability and flexibility, and (c) a wide dynamic range. In this paper, an expected S/N will be discussed using measured spectra of stratospheric ozone in the terrestrial atmosphere.

First light of this instrument would be performed in the summer 2013 at the same summit using our 60cm-telescope in the verification process. First candidates for test measurements are Mars and Venus.

キーワード: 惑星大気, 赤外, ヘテロダイン, 分光, 観測
Keywords: planetary atmosphere, infrared, heterodyne, spectroscopy, observation